MITIGATING RISKS to EUGENE'S DRINKING WATER SYSTEM

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Three categories classify the following recommendations for mitigating risks to Eugene's drinking water system. They are presented as *Primary Recommendations* and *Additional Recommendations*. The first category, *No Losses in the Process*, pertains to the importance of administrative preparation prior to a hazardous event to shorten the time of service interruption and expedite the process of recovery. In other words, "soft approaches" for mitigation. The second category is *Increase Construction, Decrease Destruction*, which are "hard approaches" for mitigation. This includes infrastructure improvements or expansions and technological solutions. The final category, *Manage the Damage,* includes recommendations for how to relieve damage after a disastrous event. The first six *Primary Recommendations* are those that were evaluated as having either the greatest impact, were most feasible, or addressed multiple hazards. The subsequent *Additional Recommendations*, while also important, supplement the primary recommendations. They have various levels of impact and vary in the resources require for implementation.

PRIMARY RECOMMENDATIONS

Baseline performance goals are beneficial to ensure preparedness and efficient management during emergencies or disastrous situations. Establishing a solid understanding of the drinking water system's capacity and the time, human and financial capital needed to restore service will considerably shorten the time of service interruption (Refer to page 16).

In an event of an extreme disaster, the city will require financial assistance as part of the recovery effort. Applying for aid is a critical first step in the recovery process. Investing in employee training to obtain disaster relief and becoming familiar with the bureaucratic process can expedite the city's recovery time (Refer to page 17).

Increase Construction, Decrease Destruction

Expand Private Sector Role

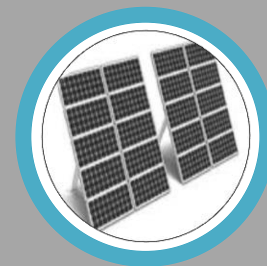
Expanding the private sector's role in technology developments, system management, and finance for decentralized systems will help avoid large capital improvement projects in the face of our aging infrastructure. This can reduce financial burden for utilities and the city. The city plays a critical role in setting the foundation for decentralized systems (Refer to page 22).

Increase Construction, Decrease Destruction

Develop Infrastructure for Alternative Water Sources

Developing infrastructure for alternative water sources creates a backup supply for the city. Alternative water sources may compensate for partial system failures in and event of a natural hazard and can help the city reduce its dependency on a single source. The city has opportunities to use the available aquifers to construct shallow wells should an emergency call for an alternate source (Refer to page 24).

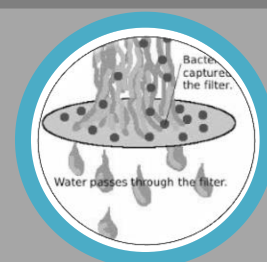
Manage the Damage



Use Solar powered Decentralized Purification Systems

Energy loss poses a serious risk to the drinking water system. Solar powered purification systems can help if or when current infrastructure is unable to meet demands during a hazardous event. The MobileMax Pure and Output 4 are two "off-the-shelf" units for the City of Eugene to consider (Refer to page 32).

Manage the Damage



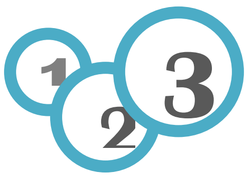
Select Satellite Treatment Systems

Satellite treatment systems can offset impairments to the central drinking water system and provide potable water throughout the city. They can decrease dependency on pipes and energy required to deliver potable water. Wastewater can be treated locally using low pressure membrane filtration systems and can also be used for large-scale satellite treatment systems (Refer to page 31).

ADDITIONAL RECOMMENDATIONS

No Losses in the Process

Reduce Institutional Memory Loss (Refer to page 18)



Phase in Implementation of Vulnerability Improvements (Refer to page 19)

Promote EWEB Backflow Prevention Pamphlet (Refer to page 21)

Increase Construction, Decrease Destruction

Identify Facilities Prone to Suffering Damage (Refer to page 25)

Adopt a Long-term (20-100 Year) Pipe Replacement Strategy (Refer to page 27)

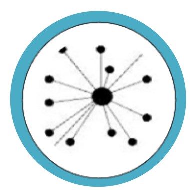
Provide Emergency Rooftop Water Collection (Refer to page 28)

Prioritize Reclaimed Water Use and Application (Refer to page 29)

Manage the Damage

Contract a Pipe Repair Crew (Refer to page 34)

Prepare Potable Water Distribution (Refer to page 34)



Disperse Portable Equipment (Refer to page 35)

Applicable Hazards Matrix	Fuel Price Increase 	Flood 	Wildfire 	Earthquake 	Drought 
No Losses in the Process					
Establish Baseline Performance Goals		●	●	●	●
Know What Funding Is Available and How to Get It		●	●	●	
Take Measures to Reduce Institutional Memory Loss		●	●	●	●
Phase Implementation of Vulnerability Improvements		●	●	●	
Aggressively Promote EWEB’s Backflow Prevention Pamphlet to Residents				●	
Increase Construction, Decrease Destruction					
Expand the Private Sector Role in Technology Development, Systems Management, and Finance for Decentralized Systems	●	●	●	●	●
Develop Infrastructure for Local Alternative Sources		●	●	●	●
Identify and Prioritize Facilities in the City that Are Most Prone to Suffering Damage that Would Result in Unacceptable Level of Service, Safety, and Cost		●	●	●	●
Adopt a Long-term (20-100 Year) Pipe Replacement Strategy				●	
Provide Emergency Rooftop Water Collection to High Rise Buildings			●	●	
Continue to Prioritize Reclaimed Water in Applications			●		●
Manage the Damage					
Consider Using Solar to Power Decentralized Purification Systems or to Pasteurize the Water	●	●	●	●	●
Select and Employ Satellite Treatment Systems in Times of Need	●	●	●	●	●
Maintain a Pipe Repair Crew				●	
Use Potable Water Distribution				●	
Disperse Stored Portable Equipment if the Utility's Operations Area Requires Access Via Tunnels, Bridges, or Slide-prone Routes		●	●	●	

INTRODUCTION AND BACKGROUND

Background

When we think of hazards and climate change, it's not uncommon to have Hollywood movies reeling through our minds. Perhaps it is images of global warming propelling Earth into a new ice age, like in *The Day After Tomorrow,* or visions of a romantic-robot roaming around Earth compacting trash into cubes, like *WallE*, or polar ice caps melting and flooding the planet, like in *Waterworld*. While most of these movies are fictional and have inaccuracies, they reflect the notion that climate change is gaining a foothold in society's concerns. If we take a step back from Hollywood and into reality, we can see how hazards and climate change unequivocally affect communities in different magnitudes and ways. Many of the climate change impacts are due to anthropogenic sources, like burning fossil fuels, which result in drastic consequences such as rising temperatures, increasing sea levels, reduced snow cover, and longer more intense droughts.[1] With these changes, the United States can expect more intense weather patterns, which can impact cities' abilities to provide adequate resources and supplies when faced with crises and natural hazards.

In response to these concerns, cities are starting to incorporate climate change strategies into natural hazard mitigation planning. In other words, cities develop both adaptation strategies for hazards independent of and exacerbated by climate change. These strategies center on mitigation, which FEMA defines as, "the effort to reduce loss of life and property by lessening the impact of disasters."[2] However, numerous strategies exist and cities have different Achilles' heel, so to identify what strategies will help cities mitigate disasters the most—cities assess risks through vulnerability assessments. Vulnerability

[1] Karl, Melillo, and Thomas. "Global Climate Change Impacts in the United States," (eds.). Cambridge University Press, 2009.
[2] Federal Emergency Management Agency. *What is Mitigation?.* http://www.fema.gov/what-mitigation

assessments focuses on individual systems within a city, like transportation, drinking water, food, public health, etc. Ultimately, it sheds light on the adaptive capacity of systems when faced with uncertainty. Adaptation strategy is a way for communities to position themselves for long term resilience.

Local Context

The City of Eugene is answering this call to arms by identifying vulnerabilities to the drinking water system. It is becoming increasingly concerned about global climate change. Over the past decade as Eugene has experienced some of warmest temperatures ever recorded. Scientific indicators suggest that this trend will continue.[3] In the Northwest, precipitation is expected to increase in the winter and decrease in the summer. Furthermore, when snowpacks decline in size and melt earlier, summer stream flows will reduce. This stresses the available water supply accessible to cities that need it. As more rainfall occurs, it can increase the amount of flooding west of the Cascades. Since reservoirs will need to maintain enough space for flood protection, more runoff will be released rather than stored and increase the hazard of flooding downstream.[4] As the temperature increases and the snow melts earlier, moisture can decrease in the summer making it more prone to wildfires. This is not including non-climate change hazards. For example, Oregon is subject to earthquakes with catastrophic risks from the off-shore Cascadian Subduction Zone. This is caused from the subducting Juan de Fuca Plate and shallow crustal events from the North American Plate.[5] Experts expect an earthquake with a magnitude of 9.0 offshore would still have a high risk capacity to cause damage in the Willamette Valley. Overall, with climate change, history is no longer a suitable predictor of risks when it is uncertain when or how widespread these hazards can impact communities.

[3] "Intergovernmental Panel on Climate Change. "IPCC Fourth Assessment Report: Climate Change 2007, 2007.

[4] Ibid.

[5] Oregon Partnership for Disaster Resilience. "Eugene/Springfield Multi-Jurisdictional Natural Hazards Mitigation Plan," October 2009.

It is not only climate change driving cities, like Eugene, to do mitigation planning, but federal and state drivers as well. First, the Disaster Mitigation Act of 2000 gives cities incentive to undertake mitigation planning because once they have a plan, they can become eligible for certain grants. Second, it can result in long-term savings. As the Eugene-Springfield NHMP mentions, "a report submitted to Congress by the National Institute of Building Science's Multi-hazard Mitigation Council (MMC) highlights that for every dollar spent on mitigation, society can expect an average savings of $4."[6] Third, the Natural Resources Defense Council and National Wildlife Federation have recently filed a petition for cities to incorporate climate risk assessments in their hazard mitigation plans. Lastly, Oregon also has statewide planning goals that require cities to consider hazards. Goal 7: Areas Subject to Natural Disasters and Hazards, requires jurisdictions to create safeguards when developing in hazard areas. Overall, it is a culmination of science, incentives, and regulations that is making a big push for cities to address climate change. As a response, the City of Eugene developed the first Community Climate and Energy Action Plan (CEAP) in 2010. The plan includes recommendations to adapt to climate change and rising fuel costs but does not address the adaptive capacity of community systems and services, nor does it outline adaptation actions. The City of Eugene is due to update its Natural Hazard Mitigation Plan in the upcoming year, which presents an ideal opportunity to incorporate a comprehensive assessment of drinking water system risks and vulnerabilities and preemptively meet potential federal regulations.

Project Purpose and Key Issues

This research will address recommendation 23.1 of the CEAP, which calls for a vulnerability assessment that analyzes the risks and vulnerabilities of energy, water, food, health, housing, and sanitation under hazardous natural events. The City of Eugene has conducted a Hazard-

[6] Ibid.

Climate-Energy Vulnerability Assessment Survey for drinking water to gauge the most significant hazards in the Eugene-Springfield metro area. The objective of this research is to identify the best and promising practices for mitigating risk to drinking water systems during natural hazard occurrences. We aim to consider mitigation practices to drinking water systems from cities that experience the natural hazards pertinent to Eugene. In order to understand the best practices this report is to deliver, it is important to have an understanding of the most serious issues and challenges each of the natural hazards poses to Eugene.

The Hazard-Climate-Energy Vulnerability Assessment Survey for drinking water covered four different hazards, which are exacerbated by and are independent of climate change. They include fuel price sensitivity, flood sensitivity, wildfire sensitivity, earthquake risk and sensitivity. Each issue was discussed with appropriate staff from the city and partner agencies. Our research used notes from these meetings to gain a better understanding of issues and challenges most pressing for the city. The following section discusses main points and risks for each of the hazards.

Hazards from Vulnerability Assessment Survey

Rising Fuel Prices: The risk of fuel prices surpassing current levels is a hazard because of the system's sensitivity to increased costs. Increased costs that impact construction and treatment will be passed on to customers through user fees. Another issue is the amount of infrastructure currently dependent on fossil fuel as its main source of power. Finding new ways to reduce dependency will be valuable to the customers, not only in terms of their costs but may help continue to provide service in times of stress like power outages. Overall, these issues make financing even more important than it already is.

Flood: With climate change, the Eugene area faces increased risks of a large flooding event. The drinking water system will be impacted most heavily from a 500-year flood event or larger. A flood of that magnitude has the capability to impact transportation systems as well as the electrical systems which compromises drinking water services. A flood's affects on our transportation network would also have significant consequences for the drinking water system. Drinking water depends on transportation systems for many reasons. One of the biggest is the ability to receive chlorine for the water purification plant. Currently, the plant can only store a month's worth of chlorine. Therefore, if transportation is disabled for an extended period of time, (Eugene Water and Electric Board) EWEB could run out of chlorine. Electricity affected by flood is another risk to the system. A loss of power can cripple the system and without transportation networks, fuel vehicles may have a difficult time delivering fuel to the backup power supplies.

Wildfire: The city's drinking water could face a number of challenges from wildfires. The most significant is loss of power to various areas in the drinking water system. Pumping water from the river, as well as operations of the water treatment plant, rely on electricity to function. Electricity is used to pumping water to the treatment plant and is not backed up by an alternate source of fuel should the power go out. If service in the face of a power outage exceeds 12 hours, both the pumping station and the water treatment plant would need another form of backup power to maintain service. Another issue in the event of a wildfire is the heightened demand for water in order to help fight the fires. A main fire-oriented concern is reservoirs' capacity and quantity available for fighting fires. EWEB needs enough water to fulfill the city's needs but firefighters may need water to fight fires. When fighting fires, water is used along with fire retardants. The concern with using fire retardants is whether or not that pollutes the watershed and if the treatment process can effectively remove that pollution.

Earthquake: Earthquakes pose a serious risk to the drinking water system. A major event could destroy much of the system's infrastructure, from pipes in the ground to the facilities above ground. Once again, losing electricity is a significant issue. There is also the issue of fixing infrastructure in disrepair. Relaying or fixing underground pipes is a long and difficult process and has to be completed in order to restart service. Finally, paying for all of the repairs could total a sum of money too large for the city or utilities to handle themselves. While there may be disaster relief money available, it may not be enough.

Drought: Although not listed as a direct hazard in the vulnerability assessment, drought was another hazard that continued to be prevalent in our research. With climate change affecting variability and quantity in the future, we also included this as a hazard since several best practices addressed this hazard too.

Climate change in general is an overarching issue that both causes and exacerbates natural hazards. Therefore, it is difficult to assess this as an independent hazard. One way to address climate change is conservation. Finding new ways to reduce the city's water use will help ease the burden of dealing with what changes may occur with the climate. A second way is to increase redundancy for water sources. EWEB is currently the largest single source water supplier in the nation. The possibility of adding another source could give EWEB more maneuverability if problems did arise like low flows or pollution.

Although all hazards are serious and require preparation, the city has identified earthquake risk and fuel price sensitivity as the two most critical hazards. Both of those risks have the most damage potential and arguably the least preparation-date from a drinking water perspective. Planning for climate change across multiple systems and services will require a diverse group of actors as well as innovative ideas.

Research Objective

In sum, with the risks of climate change increasing the probability of extreme weather events, the City of Eugene must prepare community systems for such long-term climate challenges. The community's local emergency management programs are relatively well prepared to manage short-term emergencies. However, there is a gap in the community's medium and long-term emergency plans. An initial step in addressing this gap was conducting the Eugene-Springfield Vulnerability Assessment. The assessment identified key weaknesses for vulnerabilities to major infrastructure and service systems.

Therefore, this project will be the next step in addressing how to mitigate risks to the drinking water system, one of the major systems in the Vulnerability Assessment. Natural hazards are impossible to predict and to what extent they will affect communities. Thus, mitigation is important because it is a preventative measure to reduce the impacts on infrastructure, lives, and property resulting from natural hazards. The City of Eugene is due to update its Natural Hazard Mitigation Plan in the upcoming year. Therefore, the purpose of this research is to investigate best practices that cities across the country have developed to reduce risks to their service systems when threatened by natural hazards and ultimately to create resilient communities.

Study Approach and Methods

The most prevalent risks and vulnerabilities that emerged from the Drinking Water System Vulnerability Assessment guided our research on what types of best practices, lessons learned, and strategies were needed to meet the city's needs. To research these best practices, lessons learned, and strategies, we reviewed plans, reports, and peer-reviewed articles in three phases and developed our findings around these guiding questions:

- What are best practices from cities to mitigate risk to drinking water systems during natural hazards?
- What role do external partners of the city play in implementing mitigation action items?
- What are funding opportunities and constraints, as well as drivers and barriers to implementation?
- Are there best practices that address more than one type of natural hazard to mitigate risks to drinking water systems?

Our first phase was researching cities that experience similar hazards but on a recurring basis, for example, Japan and California for earthquakes. Our second phase focused on researching other disasters that still would address similar risks and vulnerabilities (e.g. dependence on secondary systems). One example of this is looking at lessons learned from disasters that caused power outages in Hurricane Katrina. Our last phase focused on obtaining best practices that lessen environmental impacts and promote green building developments that provide the added benefit of reducing risks and vulnerabilities to the drinking water system. Some of this information was used to identify the roles that internal and external partners can play in implementing mitigation action items, mechanisms for funding implementation, and the risks that transcend different hazards.

Limitations

Throughout our research we came across several limitations. Several recommendations we found appeared to be things that EWEB or the city is already doing. This made research to find new ideas foreign to the city and EWEB was difficult since many cities are just now starting to take similar measures. There were also challenges with finding solutions that were on the same scale as the city. Many of these hazards occur at a regional scale, and within the affected regions cities with characteristics comparable to Eugene are limited. Futhermore, not all cities make strategies and lessons learned available to the public. Some of the solutions were vague and not clearly marked within the documents they were a part of. Even though a number of solutions from larger cities can be modified and adapted for Eugene's size, it was still a limiting factor.

Of the solutions made publicly available, many of them simply addressed a single hazard rather than provide solutions for many of the hazards. Information on vulnerabilities to drinking water systems from earthquakes was plentiful, but information tended to lack with regards to other hazards. When looking at other plans, like hazard mitigation plans, cities/regions tended to approach each problem separately rather than in a cross hazard approach. It is important to note that information on these topics is constantly growing and evolving. As major events occur and people study what worked and what didn't work, better practices are being developed. Most recently, for example, is Colorado, which experienced major flooding and has begun rebuilding. Lessons about how drinking water systems react to that kind of major flooding event are just emerging. The city should continue to search for that information as it becomes published, since climate change will continue to occur and force locations to adapt.

Although EWEB was involved with the vulnerability assessments, for future projects of this type, a closer working relationship with EWEB would be beneficial. EWEB heads the drinking water system for the city and without their input and knowledge on researched best practices and findings, some information could have been left out. Integrating information from both the city and from EWEB is the best way to create recommendations that are useful to both parties.

FINDINGS

Background on EWEB

EWEB, the largest citizen-owned utility in Oregon, supplies drinking water to Eugene residents through 800 miles of piping and 26 reservoirs for storing water.[7] Currently, EWEB has one water source, the McKenzie River. In the event of a major disaster that would disrupt the utility's ability to obtain water from its sole water source, EWEB can supply water for two days. Because this time-dependency is such a critical path for supplying water to residents, EWEB is currently in the process of identifying an alternative water source and a backup treatment plant.[8] Additionally, EWEB has also focused on emergency preparedness regardless of the type of disaster. The utility's website has information regarding emergency preparedness available to residents, such as when and where they can expect a response trailer and how to prepare for an emergency.[9] Furthermore, the utility also has a curtailment plan that outlines actions in times of water shortages to reduce the demand and identify alternative water supplies.[10] EWEB does have a 10-year Capital Improvement Plan (CIP) that focuses on three types of spending. The first type is general capital, the second type focuses on infrastructure rehabilitation and expansion projects, and the third type focuses on strategic programs, which provide long-term system-wide benefits. [11] The first two types of spending are based on rate payer funds and the last one on bonds.

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[7] EWEB. "Maintaining and Upgrading Our Water System." *EWEB.* http://www.eweb.org/waterupgrade.

[8] Adams, Tom. "9.0 quake + EWEB = 2 days water: 'This keeps me up at night'." November, 6 2013. *KVAL.* http://www.kval.com/news/local/90-quake--EWEB--2-days-water-This-keeps-me-up-at-night-230845421.html.

[9] EWEB. "Emergency water distribution frequently asked questions." *EWEB.* http://www.eweb.org/waterreliability/emergencyfaq

[10] Water Solutions, Inc. "Water Management and Conservation Plan Excerpted Chapter 4 Municipal Water Curtailment Plan." January 2012. http://www.eweb.org/public/documents/water/waterCurtailment.pdf

[11] EWEB, Water and Electric 10-Year Capital Improvement Plan (CIP), 2013. http://www.eweb.org/public/commissioners/meetings/2013/130716/M7_WaterElectricCIP-10year.pdf.

As the sole provider of water to Eugene and Springfield, it is important that EWEB reduce its vulnerabilities to hazards and fuel price increases. Despite the efforts EWEB has made, there is still room for improvement as with any utility. Specific mitigation practices and improvements for potential hazards that could impact the water supply in our area are key to preventing significant loss of life and property. Our research addresses coordination between city and utility planning through strategies required for collaboration and preparedness in the event of a hazard.

NO LOSSES IN THE PROCESS

Establish Baseline Performance Goals

Rationale: The results of disaster and emergency situations can be far ranging. While it is impossible to completely prevent damage from a hazardous event, steps to ensure preparedness will help manage it when they do occur. Understanding the system's capacity in an event of an emergency and the time and energy needed to restore full capacity is critical for devising organizational and service operations. Setting performance goals will lead to considerably shorter restoration times and efficient use of resources. Performance goals can help determine the necessary intermediate steps to achieve goals and measure progress. Setting performance goals will reduce post disaster effects and ultimately minimize the threat of damage.

Description: Performance goals provide a guide for what constitutes acceptable water system performance after an earthquake or other related hazard to help restore water services as rapidly as possible.[12] Performance goals for individual water utilities should be developed to identify and prioritize those facilities most prone to suffering damage resulting in an unacceptable level of service, life safety hazard and/or cost to the water utility's customers.

[12] Eidinger, John, and Craig A. Davis. Recent Earthquakes: Implications for U.S. Water Utilities. Denver, CO: Water Research Foundation, 2012.

Such as fire services, hospital, and disaster centers. Goals should determine how long the city should take to reach minimal service, limited service, and get back normal service to the most critical facilities. The judicious use of personnel, spare parts, and other resources to rapidly fix the damage after an event will help reach specific performance goals. Appendix A provides example of Performance goals adopted by East Bay Municipal Utility District, EBMUD and Humbolt Bay Municipal Water District, HBMWD, for both a maximum earthquake and a probable earthquake. Performance goals can be set for each hazard that the drinking water system is most vulnerable to.

Applicable Hazards

Know What Funding is Available and How to Apply for It

Rationale: When a disaster occurs, few of the procedures have been tried and tested, and it is difficult to tell how people will react. These facts make it challenging to begin the recovery effort. Part of the recovery may involve applying for aid if the disaster is destructive enough to cause any damage. There are opportunities before a disaster to work with organizations such as FEMA, which can help a city prepare for disasters. FEMA offers an Infrastructure Systems Recovery Support Function,[13] which is aimed at learning where a system is weak and what areas need to be improved upon.

Description: Taking time before a disaster to train employees on how to obtain disaster relief can reduce the city's recovery time. An employee who has studied the

[13] FEMA. National Disaster Recovery Framework. Infrastructure Systems Recovery Support Function. Washington, D.C. http://www.fema.gov/pdf/recoveryframework/infrastructure_system_rsf.pdf

forms and knows what the requirements are for the different types of aid will be more effective in a time of crisis than an employee who is trying to research and learn aid forms during a crisis. Having an employee who has these skills is important to have for all emergencies that require aid. The employee would be valuable in coordinating the FEMA effort along with other organizations that make themselves available to help because of the working relationships that have been developed.

Applicable Hazards

Take Measures to Reduce Institutional Memory Loss

Rationale: The efficacy of responding to crises depends on the aptitude and knowledge of employees.[14] Grigg recommends that groups, like the city and EWEB, should create a collaborative response plan that coordinates efforts that address unstructured decision scenarios. This outcome results in a mutual understanding of one another's priorities so strategies can be developed in a way that meets everyone's needs and concerns. For example the Eugene Wildfire Sensitivity Assessment documented the capacity to provide water to both residents and firefighters as a concern. Although the city and EWEB may not have issues with high turnover or a majority of staffing nearing retirement, preventative measures will ensure smooth responses in time of crises and ensure both groups have a common understanding of priorities.

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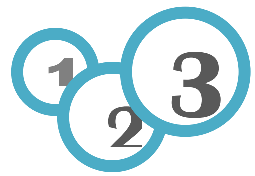
[14] Grigg, Neil. "Disaster preparedness and emergency response in the Water industry." *Journal of American Water Works Association*. 98, no. 3 (2006): 242-246, 249-255.

Description: The city and EWEB should discuss priorities and concerns for different hazards. For example, the coordination of priorities for water supply and use when supply is limited during wildfires. After the development of a plan, both groups should execute several drills to identify lessons learned. By doing so, it will help identify factors like role assignment, lines of authority, and an incident command system.[15] Executing drills like these allows seasoned veterans the opportunity to share experiences and knowledge to maintain institutional memory. The American Water Works Research Foundation has an Emergency Response and Recovery Planning for Water Systems: A Kit of Tools report that can be used to help cultivate a plan, if one is not already developed.

[15] Grigg, Neil. "Surviving Disasters: Learning from experience." *Journal of American Water Works Association* 95, no. 9 (2003): 64-75.

Applicable Hazards



Phase Implementation of Vulnerability Improvements

Rationale: Many options are available when a city decides to make infrastructure improvements to reduce its vulnerability to hazards. Making large sweeping changes to infrastructure can easily exceed a cost that the city can afford. To help mitigate the large costs, the city can slowly phase in the desired vulnerability projects.[16] Cities already understand that there is considerable value in efficiency. This slow and steady approach to implementation can keep increasing the city's preparedness even when there is not a large pool of funding for the whole project.

[16] The Oregon Resilience Plan, 213.

Description: EWEB currently has a three tier system it uses for planning out how to pay for projects.[17] The first tier is rate funded, the second tier is rate funded or through long-term bonds, and the third tier is bond-funded. The drinking water system currently employs phased implementation; an example of this is shown with how EWEB updates its pipe infrastructure. When the city of Eugene performs its planned road updates, EWEB installs new pipes under the road while it is under construction so that process does not have to be done twice. With more vulnerability improvements becoming necessary, financing will become more important. Maintaining the phased implementation way of financing projects, especially the more expensive projects, will keep EWEB progressing in multiple facets of their system. The Oregon Resiliency Plan recommends the phased implementation technique be first used on the "backbone" of the water system.[18] The backbone refers to the most critical and essential functions of the system, which should be primary targets for updating prior to a disaster, and for repairing after a disaster occurs.

Applicable Hazards

Aggressively Promote EWEB's Backflow Prevention Pamphlet to Residents

Rationale: At points of cross connection, or places where public drinking water comes in contact with substances that are unwanted or dangerous in the water system, there is a chance that backflow could occur. Backflow happens when there is a sudden change in the pressure within a water system which can cause water to flow backwards and pull water back into the system that

[17] Damewood, Mel, ed. Eugene: EWEB, 2013. s.v. "Water and Electric 10-Year Capital Improvement Plans (CIP) ." http://www.eweb.org/public/commissioners/meetings/2013/130716/M7_WaterElectricCIP-10year.pdf.

[18] The Oregon Resilience Plan, 213.

has been in contact with dangerous substances.[19] A good example is the rupturing of pipes during an earthquake. Sudden changes in pressure can occur due to water distribution system maintenance or water being taken from a fire hydrant to fight a fire.[20] The Municipal Water District of Orange County has developed a plan that addresses hazard mitigation planning for their drinking water; part of that plan includes improving backflow prevention measures in case of an earthquake[21].

Description: EWEB has done a good job ensuring that there is good backflow protection for the drinking water system.[4] However, some cross connections still exist in the system most of which are a result of unregulated incidents from private single home residences. EWEB produced a pamphlet that shows many examples of backflow and teaches people either how to rectify the problem or just to know what to look for.[22] The issue of preventing backflows at private single home residences has been addressed by EWEB, but sharing the "Keeping Your Water Drinkable" pamphlet more aggressively with customers could help to reduce the chances of a major problem when a serious event does occur.

Applicable Hazard


[19] EWEB. "Backflow Prevention." http://www.eweb.org/waterquality/backflow.

[20] El Paso Water Utilities Public Service Board. "Cross-Connection Control Program." http://www.epwu.org/water/cross_connection.pdf.

[21] Municipal Water District of Orange County. "Section 5 General Overview of Assets, Goals and Objectives." http://www.mwdoc.com/cms2/ckfinder/files/files/Section%205%20HM(1).pdf.

[22] EWEB. "Keeping Your Water Drinkable." http://www.eweb.org/public/documents/water/waterdrinkable.pdf.

INCREASE CONSTRUCTION, DECREASE DESTRUCTION

Expand the Private Sector Role in Technology Development, Systems Management, and Finance for Decentralized Systems

Rationale: Encouraging decentralized systems can fall in line with the Green Building movement that the city has already started to promote. For the purpose of drinking water systems, it would remove buildings from the grid for water systems and potentially use part of the water to help provide energy, like Berkeley's Eco-Blocks. Decentralized systems help avoid large capital projects when aging infrastructure is a prevalent problem; therefore, taking some of the financial burden off of the utilities and cities. It not only reduces financial burden but implementation is cheaper than centralized systems, allows opportunity to capitalize off the water-energy nexus which can help reduce reliance on rising fuel prices, and allows for water reuse that can reduce demand on potable water supply. Furthermore, since the vulnerability assessment documented access to chlorine as a concern during hazards, it can reduce dependence on chlorine disinfection by using other disinfection technologies in the future. According to the Cascadia Green Building Council, federal regulations still require chlorination for on-site treatment.[23] Such an approach requires integration with wastewater and stormwater planning, design, and engineering which not only helps create a more water-centric community but reduces risks for these systems as well.

Description: The first step for the city is to lay the foundation for decentralized system uses and acceptance in Eugene. The city would need to make the private sector marketable which would mean it would need to provide financial incentives, market these concepts to the public,

[23] Cascadia Green Building Council. Toward Net Zero Water: Best Management Practices for Decentralized Sourcing and Treatment. March 2011.

use ordinances if voluntary measures don't work, provide inspection programs, and developing a planning framework for decentralized systems' role in the city. One example the city could use to encourage investments in decentralized systems is a strategy similar to the Vancouver Valuation Accord. It encourages investment in decentralized systems by requiring real estate developers to show how any development approach reduces risk to the area.[24]

Once the city creates a foundation, it would need to encourage developers and builders to implement off-the-grid designs under the understanding that EWEB would relinquish responsibility in building and managing these decentralized systems. However, to ensure proper service to the public the city or utility can still oversee the private sector's process in designing and maintaining the services. One strategy to facilitate this type of development is to start using this in infill developments or new suburban areas especially because there is a growing interest in homeowners to have green buildings and infrastructure.[25] However, past experiences have shown cities need to take active measures to protect public interests which include enforcing accountability, achieving equity, and ensuring land use complements larger watershed goals.[26]

The Cascadia Green Building Council provides a best management practices report[27] and other information on decentralized systems that can serve as a starting point to help the city address these issues and identify best practices that would fit the city's needs.

Applicable Hazards

24 Nelson, Valerie. Institutional Challenges and Opportunities: Decentralized and Integrated Water Resource Infrastructure.X-830851. 2008.

25 Nelson, Valerie. Institutional Challenges and Opportunities: Decentralized and Integrated Water Resource Infrastructure.X-830851. 2008.

26 Nelson, Valerie. Institutional Challenges and Opportunities: Decentralized and Integrated Water Resource Infrastructure.X-830851. 2008

27 See: http://www.ecobuildingpulse.com/Images/TNZW_tcm131-1075029.PDF

Develop Infrastructure for Local Alternative Sources

Rationale: Alternative water sources may compensate for partial system failures in an event of a water outage. It may be possible to convey alternate local water sources for a backup supply using shallow wells. Diversifying the city's water portfolio will reduce the city's dependence on a single source, thus making the city less vulnerable to disrupted services. For example, the City of San Francisco is currently developing the *San Francisco Ground Water Supply Project*[28] to diversify their portfolio and ensure the availability of a local source for water should a disaster interrupt their main supply. Arrangements for alternative supplies in short and long term emergency situations should be considered to set up a framework agreement between local authorities and water companies.

Description: Shallow wells are an option for the city to consider in order to establish a secondary water source in an event of a threat to the main source. Shallow wells are excavation or structure created in the ground by digging, driving, boring, or drilling to access groundwater in underground aquifers. Where there is an open water hole dug into the groundwater table (i.e. not simply a depression that accumulates run-off), concrete rings or caissons can be inserted into the well once it has been deepened. The well water is usually drawn by a hand pump or rope and bucket, and can be done directly by individuals. Treatment may be minimal or unnecessary if properly located, constructed, and maintained. Shallow wells can be connected to a generator for backup power, provide on-site disinfection, and be connected to a dedicated hydrant for filling water tanker trucks. However, yields may vary seasonally and a high water table is necessary. Care and improvements are needed to avoid contamination and the outside of the well may need to be sealed. Where the existing source is an open, unprotected well, it can be improved by sealing the

[28] See: http://www.sfwater.org/bids/projectDetail.aspx?prj_id=322

upper three meters of the walls and providing a cover, surface drainage and an improved low-maintenance pump.

Applicable Hazards

Identify and Prioritize Most Prone to Suffering Damage and Unacceptable Level of Service, Safety, and Cost

Rationale: When disaster strikes victims need treatment or shelter; therefore, it is important to make sure that infrastructure in key facilities, like hospitals or disaster centers, is ready to withstand disasters. Hospitals need water for several activities including hand washing and patient care. Although the Joint Commission already requires hospitals to address water supply in the case of emergencies in Emergency Operations Plans, [29] the city can help by reducing the risk for infrastructure damage. In the case of earthquakes, this includes upgrading underground pipes to handle seismic activity near these facilities. For all hazards, it is important to reduce the water demand when the supply might be limited since a large amount of people will be utilizing these facilities, like during droughts. Because it could take days to months to repair the drinking water system it is important that these facilities can operate with minimal dependence on the system.

Description: Mitigating these risks entails identifying hospitals, treatment centers, disaster centers, community centers, etc. where drinking water is vital to provide services. The city can analyze the as-is performance or anticipated demand for each facility if a hazard occurs. Based on the results, the city can prioritize facilities in order of importance. The city can start by upgrading higher priority facilities and establishing target performance goals

[29] American Water Works Association.CDC. *Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities.* 220957. http://www.cdc.gov/healthywater/pdf/emergency/emergency-water-supply-planning-guide.pdf.

for each service category (see Establish Baseline Performance Goals). Any adjustments to upgrade or rehabilitate infrastructure can be included in a CIP with cost estimates. Aside from addressing the as-is performance of the facilities, the city can create maps of isolation valve locations, connective piping locations, and areas in need of special pipe fittings to connect to the building if it needs emergency access to potable water. Other strategies to reduce supply include the installation of low flow water fixtures and incorporation of gray water recycling.

Applicable Hazards

Adopt a Long-Term (20-100 Year) Pipe Replacement Strategy

Rationale: The high damage susceptibility of existing buried pipe infrastructure due to earthquake-caused ground failures (liquefaction, landslide, surface faulting, and other effects) is a major weakness for nearly all U.S. water agencies in high seismic zones.[30] Critical damage can potentially occur on the infrastructure absolutely necessary to operate or maintain the system at its most basic capacity. The lack of predictability to determine a specific hazard zone in the event of an earthquake underlies the rational to adopt a long-term pipe replacement strategy. Investing in a resilient network of pipes will offset post disaster financial burdens, such as costs associated with emergency responses and repair costs. Taking the costly outlay of pipe replacement into consideration, it is not well-founded to consider

[30] Eidinger, John, and Craig A. Davis. *Recent Earthquakes: Implications for U.S. Water Utilities.* Denver, CO: Water Research Foundation, 2012.

replacement on the basis of seismic vulnerability alone. Therefore, leak history plays a decisive role in the replacement strategy to determine the priority of pipes that are to be replaced.

Description: Damage to water systems, and the resulting water outages to customers, is predominantly caused by failure from distribution pipes in zones where ground is impacted (based on three recent major earthquakes—Chile 2010, Christchurch 2010–2011, Japan 2011). The city should identify areas with moderate to high or very high liquefaction and/or landside threats, or traverse active fault lines to determine priority areas for pipe replacement. Decisions to replace pipes should be made based on recent leak history, not seismic risk alone.

Pipes with excellent earthquake performance include HDPE pipe for common distribution pipes and service laterals (from under 1” to 8” diameter) and ductile iron for distribution and transmission pipes (from 3” to greater than 100” diameter). The American Life Alliance (ALA) 2005 offers seismically designed guidelines for water pipes. However, the ALA 2005 only addresses seismic issues. The pipe replacement strategy should factor in ongoing issues of aging pipeline replacements coupled with earthquakes to determine a cost effectiveness approach. The basic calculation for determining an appropriate amount of pipe replacement per year is given by the Benefit Cost Ratio (BCR) Model in which expected future benefits are divided by replacement costs.[31]

$$BCR = \frac{\sum_{i=1}^{n\ years} \frac{RepairCostPerYear}{(1+r)^i}}{ReplacementCost}$$

where r=discount rate, and n=number of years assumed in the discount calculation. To include both aging and seismic issues, the total BCR should be the sum of seismic BCR and aging BCR: BCRTotal=BCRseismic+BCRaging. Details for calculating BCRseismic and BCRaging can be found in FEMA (2006) and Eidinger (2011), respectively.

[31] Ibid.

Applicable Hazard

Provide Emergency Rooftop Water Collection to High Rise Buildings

Rationale: During a prolonged loss of power coving the city, water pressure may be greatly reduced. This reduction in pressure may make residents in taller buildings on higher floors lose access to water. While there are still elevated reservoirs in the area, the pressure from these will decrease as the water level in them drops, so water may not be able to reach the top floors. Pumps may be used to drive water up to the floors, but those may run out of fuel should a hazards of great enough scale occurs. The amount of available drinking water may run out if the power remains out for long enough. A strategy like this also helps with power failures and could provide an increased water supply when wildfires may require a large volume of water. Creating access to water for residents in taller buildings comes from a new New York plan that is trying to require buildings to be able to connect to water mains and provide emergency water to residents within their buildings from designated emergency fixtures.[32]

Description: Creating street hookups for buildings that may not be able to push water to residents living on higher floors is an important idea. If the water system remains down for long enough to drain the city's water reserves, then buildings need their own source of water which could create a longer self-reliance time. This, in turn, gives utilities more time to find a solution to whatever problem is occurring. Large residential buildings could place smaller versions of reservoirs on top of their roofs which could provide water to the building if the buildings normal source

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[32] New York: URBAN GREEN NYC BUILDING RESILIENCY TASK FORCE, s.v. "Supply Drinking Water Without Power." http://www.urbangreencouncil.org/servlet/servlet.FileDownload?file=015U0000001Eyaf (accessed).

is cut off. The reservoirs could be filled from utility-provided water or collected rain water. One of the challenges to overcome would be cleaning the water to a drinkable level before delivery to the residents. Water that sits in a tank, whether it is storm water or cleaned drinking water, needs to be cleaned because there is a risk of pathogens growing in the water.

Applicable Hazards

Continue to Prioritize Reclaimed Water in Applications

Rationale: After water is used by various city processes, it moves to a wastewater treatment facility, where many locations dispose of the newly treated water. There has been a move by an increasing number of wastewater utilities to reuse the freshly cleaned wastewater for non-potable uses. The city of El Paso is located in a desert, and because of that fact, they view reclaimed water as a valuable resource rather than a byproduct that needs to be disposed of.[33] El Paso uses their reclaimed water like many cities with this type of technology do: industrial uses, irrigation, and construction, among other uses.[31]Saving potable water for potable water use has many benefits, but for the purposes of this project there are also hazard mitigation benefits. Storing large amounts of reclaimed water like St. Petersburg does during the day,[34] creates access to reclaimed water which can help the city cope with a drought and also the associated wild fires that can accompany the drought.

Description: EWEB has discussed the possibility of using reclaimed water before with the Metropolitan Wastewater Management Commission (MWMC) which is the local

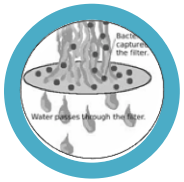
[33] El Paso Water Utilities Public Service Board. "Reclaimed Water." http://www.epwu.org/reclaimed_water/rwater.html.
[34] St. Petersburg, Florida. "Reclaimed Water." http://www.stpete.org/water/reclaimed_water/.

wastewater treatment plant.[35] MWMC currently uses reclaimed water for use on a crop of poplar trees that the Commission owns.[33] Within the memorandum to EWEB from MWMC that discusses the possibility of using reclaimed water, the list of benefits reflects many environmental benefits, but did not explicitly mention the hazard mitigation benefits that can be acquired by the city. The reclaimed water project may be further along than documents online show, but if that is not the case then this project may be worth revisiting for both the environmental as well as the hazard mitigation benefits.

Applicable Hazards

[35] Taylor, Brad. "Metropolitan Wastewater Management Commission (MWMC)- Recycled Water Program Planning Update ." Metropolitan Wastewater Management Commission. http://www.eweb.org/public/commissioners/meetings/2012/120306/Corr_MWMC-RecycledWaterProgramUpdate.pdf.

MANAGE THE DAMAGE



Select and Employ Satellite Treatment Systems in Times of Need

Rationale: Wastewater treatment to recover water, energy, and other resources is largely carried out at centralized treatment facilities. An alternative is local treatment at satellite facilities where wastewater is removed from a collection system, resources are recovered locally, and the residuals are returned to the collection system. Satellite systems decrease the pipe and energy required for delivery of treated water and may decrease cost.

Description: Large-scale satellite treatment options include low-pressure membrane filtration (i.e., microfiltration and ultrafiltration) and high-pressure membranes (e.g., reverse osmosis). For example, the Department of Defense (DOD) and some state National Guard units maintain water purification systems that are typically used to for troop support during overseas troop deployment, but the systems can sometimes be deployed in a domestic emergency. In addition, the private sector has a wide-range of products, which it can deploy under various disaster scenarios. Utilities and others should take into consideration the various procedural requirements to prepare the treatment units for deployment prior to an event. Research indicates that if packaged treatment systems are not pre-purchased or planned, procurement in response to an emergency event could be delayed due to unfamiliarity with the equipment.[36] Many manufacturers maintain pilot treatment units that could be dispatched in an emergency, but depending on desired capacity and requirements, deployment and refurbishment typically takes several weeks. Purchase of units designed for the treatment requirements of a specific raw water source can require up to three months for delivery. It is essential to determine whether ancillary items (i.e., pumps, piping and

[36] EPA, "Planning for an Emergency Drinking Water Supply" (National Homeland Security Research Center, 2011), 1-51

fittings, and chlorine disinfection) are included with packaged treatment units. Some vendors provide self-contained, integrated treatment units that can become fully-functional upon arrival. Sources of treatment units may include the military (U.S. Army), State National Guard, and/or private sector vendors.

Applicable Hazards

Consider Using Solar to Power Decentralized Purification Systems

Rationale: Decentralized water purification systems powered by solar can be easily set up and applied in times of hazards which can help reduce stress when water supply is low, populations are growing, or hazards prevent existing infrastructure from meeting demand. It is not only an opportunity for redundancy but can supply small amounts of water should a power outage affect EWEB's ability to provide drinking water to the city. Lastly, it can reduce operating costs and fossil fuel emissions which may be beneficial as fossil fuel prices rise. However, these technologies are still emerging which means it may not be cost competitive and research on how effective the system operates is still evolving. For those reasons, we recommend that the city and EWEB consider these processes over time and adopt them when these limitations diminish.

Description: Most technologies have proven to be a feasible option for disaster relief.[37] For example, Mississippi used these treatment units to provide 350,000 gallons of potable water to victims over eight months in the aftermath of Hurricane Katrina.[38] These units typically focus on pumping, filtration, and purification powered by

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[37] CH2MHill. (April 2009). *Final Report: Integration of Solar Energy in Emergency Planning.* Prepared for: New York City Office of Emergency Management. New York.
[38] Ibid

solar energy and provide a variety of treatment methods. Most units range from 400 watts to 3,000 watts and provide up to 30,000 gallons each day.[39] Two off-the-shelf units the city can consider is the MobileMax Pure ($95,000) produced by World Water and Solar and Output 4 by First Water Inc. (see Table 1).

Table 1. Solar Powered Purification Systems

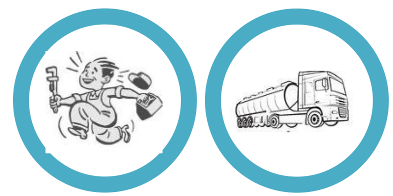
Equipment Description	MobileMax Pure (by World Water and Solar)	Output 4 (by First Water Inc.)
PV Array Size	3.4 kW	Less than 200 watts
Flow rate	15-30 gal/min 30,000 gal/day	4 gal/min 2,400 gal/day
Pump	1 HP submersible	Self-priming on board
Filtration Method	4 stage purification process (media filter, carbon cartridge, GAS/Polyphate/KDF, UV light)	Pleated ditch filter/strainer; sediment pre-filter; carbon post-filter, UV light
Weight	5,500 lbs (fits in 7'x7'x7' container)	200 lbs (26"x48"x34")
Other equipment	Inverter, charge controller, battery bank	On-board battery

Source: CH2MHill 2009

[39] Ibid

Applicable Hazards

Contract Pipe Repair Crew and Potable Water Distribution Truck Fleet



Rationale: A consequential level of damage should be anticipated in an event of a hazard. Therefore, an important component of mitigating damage and additional risk is to "manage the damage." Being prepared with the necessary social capital and provisions will allow the city to take the necessary steps to deal with impairment and restore services as rapidly as possible. Mitigating additional risk requires an emergency response plan to provide for major increases in work crews and equipment to account for the disbursed disruptions in the system, as well as auxiliary systems such as electrical networks and transportation networks.

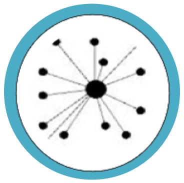
Pipe Repair Crew Description: Pipe Repair Crew: Despite mitigation efforts using seismic design principles, operators should expect some level of damage to water system after a significant earthquake since water systems consist of large and diverse networks made up of many different components, over long periods of time, crossing diverse geologic conditions. An emergency response plan should provide for a major increase in work crews. Utilities should coordinate with outside contractors and/or mutual aid for additional workforce to repair pipe damage. The sooner crews can repair damaged pipes, the shorter the water outage time will be. The city should assume a 100% increase in nominal work crew size.[40]

Potable Water Distribution Description: While pipes are out of service, potable water will need to be distributed to customer, some of whom will be displace. Utilities should consider mobile infrastructure (manifolds with hose bibs, hydrant cable attachments) and water tank truck fleet. A fleet of small water tanker trucks and small distribution tanks, and the people (fuel, etc.) needed to operate them, will be needed to serve residential zones with liquefaction and/or landslide issues. Trucks and tanks (and fuel) have traditionally been provided by emergency response agencies (not the water utility itself). The water agency should factor in coordination with outside agencies in the effort to provide potable water for delivery to end-users for drinking and sanitation purposes.[41] Furthermore, the city can consider a network of small storage tanks disbursed throughout the city in areas that can be used for emergency shelter such as recreation centers, stadiums and auditoriums.

Applicable Hazards

[40] Ibid.

[41] Ibid.



Disperse Stored Portable Equipment if the Utility's Operations Area Requires Access Via Tunnels, Bridges, or Slide-Prone Routes.

Rationale: If a hazard occurs in the near or far future to cause system failure, it will affect more than half the population and over 75% of commercial businesses. Therefore, it is important to ensure the city and EWEB can provide some level of services for the drinking water system. However, in the vulnerability assessment, members mentioned concern about providing services due to dependency on secondary systems because bridges might fail or flooding might interrupt transportation systems, for example. These failures can impede the ability to provide services if the city and EWEB can't receive goods.

Description: Portable equipment is essential to keep the system running during power outage; therefore, this equipment needs to not only be stored in fire, flood, and earthquake safe buildings but should be dispersed in multiple locations if it is not already.[42] This reduces the likelihood of damaged equipment and increases the likelihood that some equipment can still be accessed if other systems fail. In the vulnerability assessments, the committee discussed mapping secondary-to-primary infrastructure for the water systems. The city can use this map to identify areas that secondary infrastructure failures might jeopardize the accessibility of transporting or using certain equipment. The city and EWEB can use this map to collaborate and store portable equipment, like generators, pumps, and chlorinators, in multiple locations. Then if secondary failures prohibit access to some, there is redundancy.

Applicable Hazards

[42] Pickett, Mark A., Laverty, Gordon L., Abu-Yasein, Omar A., Lay, Chenwun. "Lessons Learned From the Loma Prieta Earthquake." *Journal of American Water Works Association* 83, no. 11 (November 1991): 34-39.

RECOMMENDATIONS & CONCLUSIONS

During the process of researching best management practices and risk mitigation measures, our research team tried to identify action items that would best address the large concerns in Eugene's drinking water system vulnerability assessment for medium and long-term climate change challenges. These include system failure resulting from an earthquake, dependence on secondary systems, like energy, to provide services to users, and financing for repair and mitigation measures. In addition, this research has resulted in a variety of action items that address a breadth of hazards exacerbated or independent of climate, including rising fuel prices. These actions were also developed in a way that could easily be adapted to fit in the Eugene-Springfield Natural Hazard Mitigation Plan should the city decide to include risk and vulnerability assessments and mitigation measures in future updates. The feasibility of adopting and implementing all of these action items requires time and resources that any city lacks; therefore, we have presented six action items that we recommend the city prioritizes. Two action items are recommended from each category to encourage the city to take measures to mitigate risk in a multifaceted approach. These include:

Manage the Damage

- Select and Employ Satellite Treatment Systems in Times of Need
- Consider Using Solar to Power Decentralized Purification Systems or to Pasteurize the Water

Increase Construction, Decrease Destruction

- Expand the Private Sector Role in Technology Development, Systems Management, and Finance for Decentralized Systems
- Develop Infrastructure for Local Alternative Sources

No Losses in the Process

- Establish Baseline Performance Goals
- Know What Funding is Available and How To Get It

These six action items not only address all hazards, but help prepare the city for power outages and provide options that can alleviate financial burden for EWEB and the city. Furthermore, they also provide a variety of options that will help the city and EWEB provide potable water to the city if the system experiences failure by improving the redundancy of supply and treatment.

It is important to note that it's not that the other actions don't provide these benefits, but that they don't necessarily address as many of these concerns individually. Many of these additional action items will strengthen the resiliency of Eugene's drinking water system when used in tandem with other action items. For example, the satellite treatment systems can be coupled with backup water distribution systems to not only treat the water but convey it to areas within a short distance and these satellite treatment systems can be used with a variety of local alternative sources.

Additionally, we are aware that the City of Eugene and EWEB may already be implementing some of these action items. If that is the case, it is our hope that the city and EWEB will evaluate those action items and see if there are opportunities to strengthen the current processes based on the available information. Some of these action don't require immediate action but for the city to monitor the progress and development and lay the framework so when strategies are feasible the city is prepared to take action. Overall, climate change and rising fuel prices will continue to push cities to address vulnerabilities to drinking water systems. By taking preventative measures, the city can help improve the resiliency of the drinking water system. Because water is an interconnected cycle, many of these measures will also help mitigate stormwater and wastewater risk as the city begins to identify those systems' vulnerabilities. This provides great opportunity for the city to not only improve integrated water management strategies but efficiently utilize resources and take actions that address more than one system.

APPENDIX A

Water System Service Goals-Probable Earthquake (EBMUD)	
Service Category	Probable Earthquake
General	1. Minimal secondary damage and risk to the public
	2. Limited extensive damage to system facilities
	3. All water introduced into the distribution system minimally disinfected
	4. All water introduced into the distribution system fully treated
Fire Service	5. Sufficient portable pumps and hose to provide limited fire service in all areas
	6. All areas have minimal fire service (one reliable pumping plant and reservoir)
	7. High risk areas have improved fire service (all facilities reliable, minimum fire serves)
	8. Normal service to all hydrants within 20 days
Hospitals and Disaster Centers	9. Minimum service to affected area within 1 day (water available via distribution system near each facility)
	10. Impaired service to affected area within 3 days (water available via distribution system to each facility, possibly at reduced pressures)
Domestic Users	11. Potable water via distribution system or truck within 1 day
	12. Impaired service to affected area within 3 days (water available via distribution system to each domestic user, possibly at reduced pressure)
Commercial, Industrial, and Other Users	13. Impaired service to affected area within 3 days (water available via distribution system to each commercial or industrial user, possibly at reduced pressures)

Water System Service Goals-Maximum Earthquake (EBMUD)	
Service Category	Maximum Earthquake
General	1. Minimal secondary damage and risk to the public
	2. Limited extensive damage to system facilities
	3. All water introduced into the distribution system minimally disinfected
	4. All water introduced into the distribution system fully treated
Fire Service	5. Sufficient portable pumps and hose to provide limited fire service in all areas
	6. All areas have minimal fire service (one reliable pumping plant and reservoir)
	7. High risk areas have improved fire service (all facilities reliable, minimum fire serves)
	8. Normal service to all hydrants within 100 days
Hospitals and Disaster Centers	9. Minimum service to affected area within 3 days
	10. Minimum service within 10 days (water available via distribution system near facility)
	11. Impaired service to affected area within 30 days (water available via distribution system to facility, possibly at reduced pressure)
Domestic Users	12. Potable water at central locations for pickup within 3 days
	13. Minimum service to 70% of customers within 10 days
Commercial, Industrial, and Other Users	14. Potable water at central locations for pickup within 1 week
	15. Minimum service to 70% of customers within 10 days
	16. Impaired service to 90% of customers within 30 days (water available via distribution system to 90% of commercial or industrial users, possibly at

	reduced pressure)

HBMWD Water System Service Goals-Probable Earthquake	
Service Category	Probable Earthquake
General	1. Minimal secondary damage and risk to the public
	2. Limited extensive damage to system facilities
	3. All water introduced into the distribution system minimally disinfected
Fire Service	4. Provide 100% of average winter level flows to customer meters within 4 hours after earthquake. (Tentative goal for large customers)
	5. Provide 100% of average winter level flows to all customer meters within 3 days after earthquake. (Tentative goal for large customers)
Domestic Water Service	6. Potable water via truck accessible locations within 1 day to meet minimum consumption needs (1 gallon per person per day)
	7. Impaired service within 3 days
	8. Normal service within 20 days
Raw Water Service	9. Impaired service within 3 days
	10. Normal service within 20 days

HBMWD Water System Service Goals-Maximum Earthquake	
Service Category	Maximum Earthquake
General	1. Minimal secondary damage and risk to the public
	2. Limited extensive damage to system facilities
	3. All water introduced into the distribution system minimally disinfected
Fire Service	4. Provide 50% of average winter level flows to customer meters within 4 hours after earthquake. (Tentative goal for large customers)
	5. Provide 100% of average winter level flows to all customer meters within 3 days after earthquake. (Tentative goal for large customers)
Domestic Water Service	6. Potable water via truck accessible locations within 1 day to meet minimum consumption needs (1 gallon per person per day)
	7. Impaired service within 7 days
	8. Normal service within 60 days
Raw Water Service	9. Impaired service within 7 days
	10. Normal service within 60 days

Source (for all tables in Appendix A): WRF, Recent Earthquakes